Space Weather Technical Forecast

Issued on Friday, 17 December 2021 at 01:25 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Daily Chance of M-class flares, potentially increasing.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar Activity was Low in the past 24 hours, with a gradual increase in background flare activity and C-class flares becoming more regular, the largest being an impulsive C3 at 15/1527UTC. This flare emanated from a complex group of sunspot regions located in the southeast quadrant, two of which are classified as Dai/Beta-Gamma, having undergone rapid development. There are seven sunspot groups on the disc at present.
No Earth-directed Coronal Mass Ejections (CMEs) were observed in available satellite imagery for the period, although several large peripheral eastern horizon events were noted, as well as very faint and narrow west limb occurrences.

Solar Wind / Geomagnetic Activity: Earth is currently sampling the fast wind from coronal hole 32 - a now mature negative polarity feature, with the phi angle mostly towards the sun. The solar wind speed was mostly elevated, between 500-550 km/s, but has moderated to 450 km/s in the last six hours or so, along with a slow decline in density. The IMF was weak throughout but became somewhat less volatile, while the north-south component became slowly negligible. The net result of these solar wind measures was mostly Quiet geomagnetic activity, with two Unsettled periods observed in the 03-09UTC window.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) remained at Background levels. The high energy electron flux (greater than 2 MeV) was at mainly Background levels, with the associated 24-hour integrated fluence well below the Active threshold. A fluence of 2.03e6 was observed at 17/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar Activity is currently Low but may become Moderate at any time, given the complexity of the sunspot regions present on the eastern hemisphere. Further potential regions are also expected to arrive over the eastern limb later in the period, while none should leave, meaning the risk of significant flares ought to increase over the coming weekend, with an increasing chance of M-class flares and a slight chance of X-class events.

Solar Wind / Geomagnetic Activity: No CMEs feature in the current forecast period. Earth is currently under the influence of CH32 and may remain connected to its high speed stream for another two days, before its influence starts to wane on days 3 and 4. Geomagnetic activity is expected to be mainly Quiet to Unsettled but with a chance of Active intervals, should we observe any faster solar winds on Days 1 and 2.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels, although with a slight increasing risk as the active regions migrate westward towards the western hemisphere.

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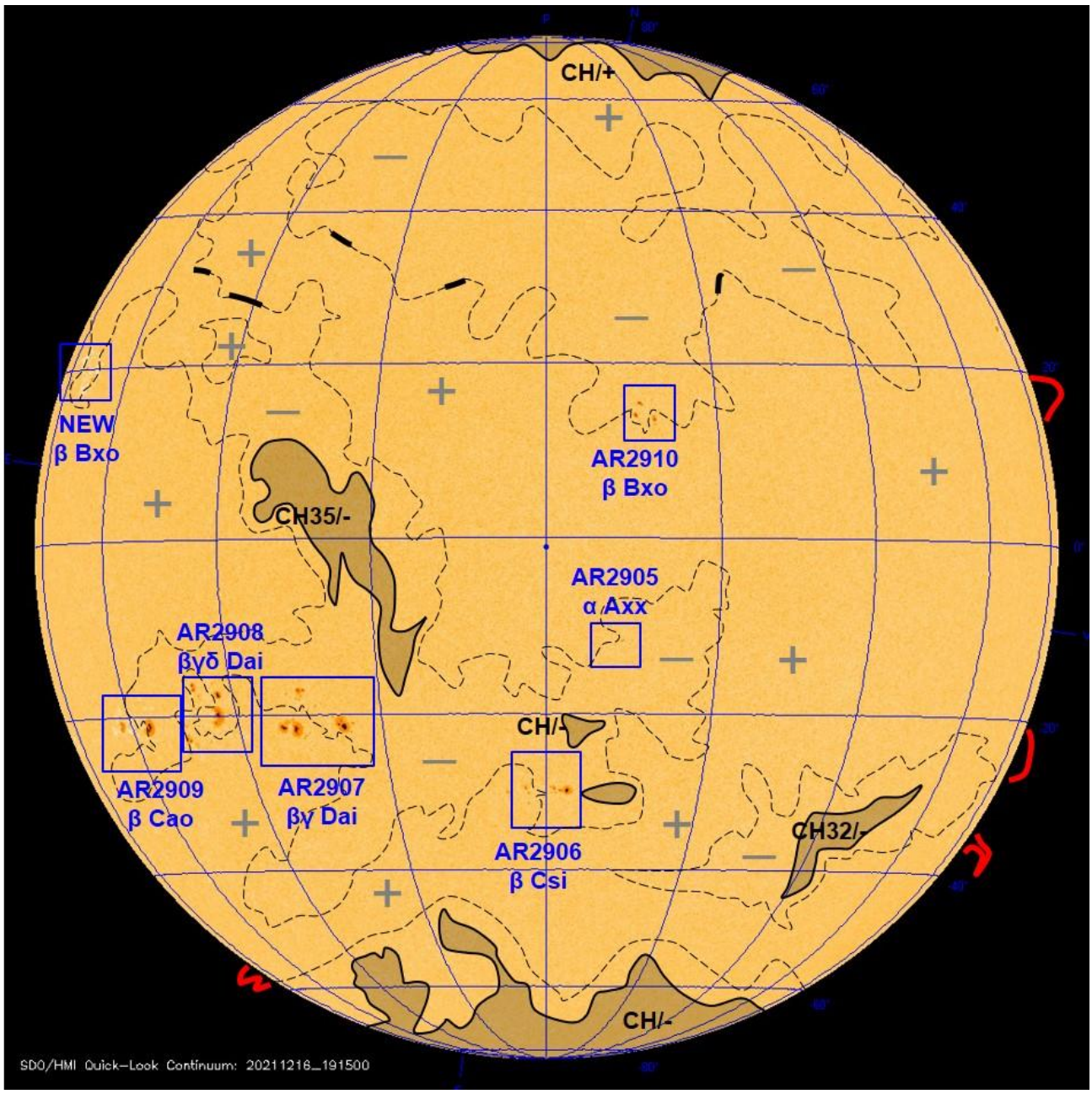
The high energy (greater than 2 MeV) electron flux, as observed by GOES-16, is expected to be at Background levels initially. While the flux is expected to rise on Days 3 and 4, it is not considered to be strong enough to allow the associated fluence rising above the Active threshold.

Figure 1. Solar Analysis Valid 16/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

No Earth-directed CMEs feature in this forecast.

The current fast wind is thought to emanate from coronal hole 32. This feature is quite elongated, judging from SDO/AIA 193 imagery, so much so that we may still be connected to the high speed stream originating from its equatorial part, whereas the fast wind from its southern extension is still yet to arrive. The back-edge of CH32 sits currently around 40 degrees West and should be able to sustain elevated solar wind speeds for at least another day, perhaps two. This would tend to corroborate the SWPM (solar wind persistence model) which indicates winds in excess of 500 km/s over the next 48 hours, perhaps reaching 650 km/s.

Geomagnetic activity is therefore expected to be mainly Quiet to Unsettled but with a chance of Active intervals, should we observe any faster solar winds on Days 1 and 2.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	5	1	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

NIL

Figure 2: Coronal Hole 32 and its elongated shape, as seen by SDO/AIA 193 imagery on the 14/0100 UTC.

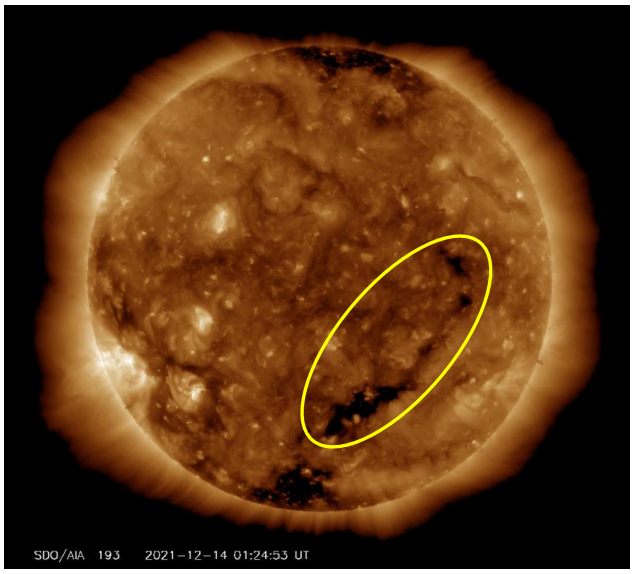

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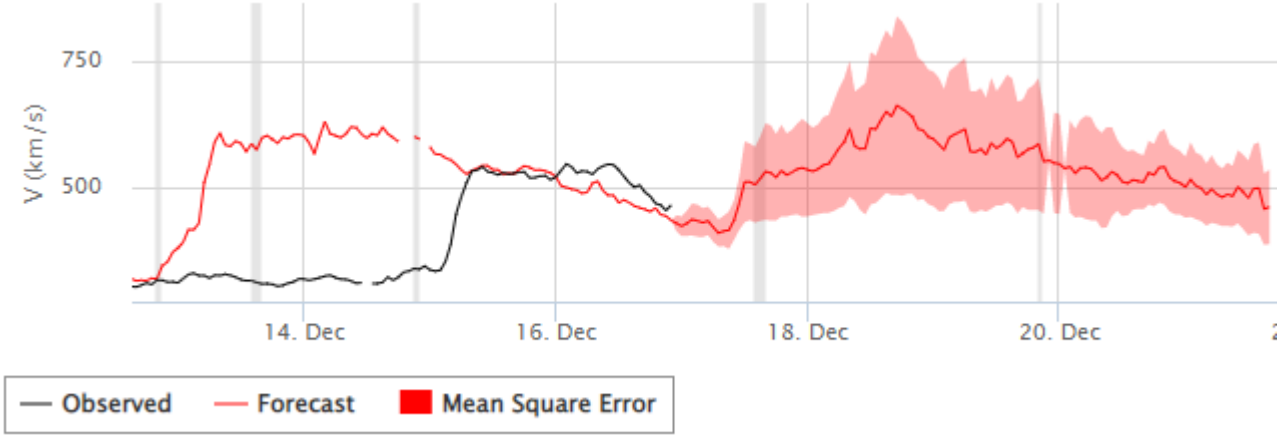
Figure 3: SWPM indicating the possibility for another increase in solar wind speeds originating from CH32.



Radio Blackouts - X-Ray Flares:

There are currently seven sunspot regions on the solar disc, six of which are numbered. The largest and most complex group of sunspots is a cluster constituted of AR2907, AR2908 and AR2909, located in the southeast quadrant. Two of these regions are classified as Beta-gamma. AR2908 also continues to display a slight growing trend.

Despite the current complexity of the disc and the rapid increase of other measures of activity (e.g. Penticton flux rising at its fastest daily rate so far this cycle as part of its rise from 76 sfu on 12 December to 118 on 16 December), this has so far not borne out as significant flares of M or X class. Despite this lack of 'ground truth', the risk is felt to be there for larger flares, with a probable rise over the coming weekend as more regions bring themselves to bear on the overall probability.

C-class flares are thus expected through the four days, with a Chance of M-class and a Slight Chance of X. The prospects for significant X-ray activity may increase later in the period. As indicated by Stereo A EUVI imagery, further potential regions should arrive in the coming days, these likely to bolster the current front side and flare risk, as no regions are due to depart.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	30	30	40	40
Very Active	R3 to R5 X Class	No	5	5	10	10

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Figure 3: Cluster of sunspot regions (2907, 2908, 2909) as seen on the last SDO/HMI imagery

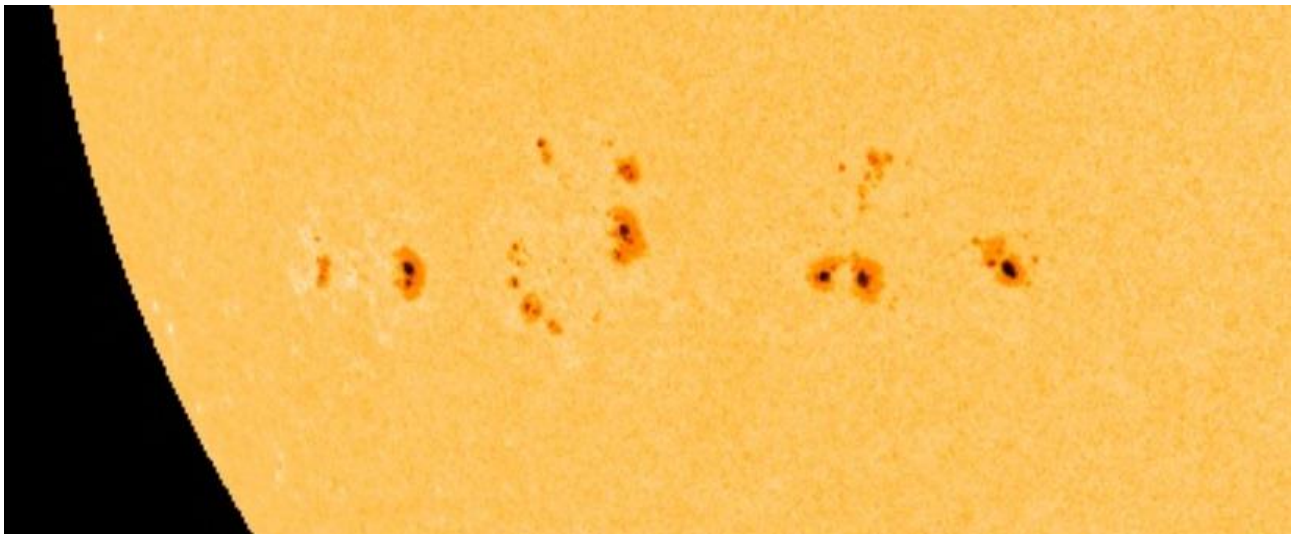
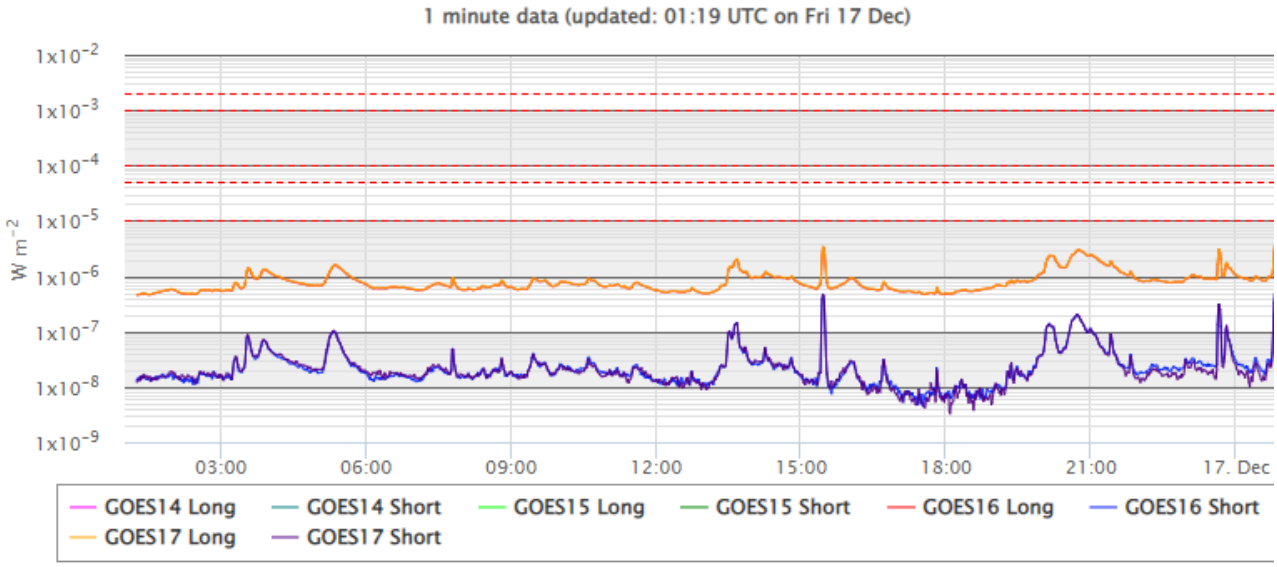


Figure 4: Latest X-Ray flare activity



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is currently expected to remain at Background levels.

Increasing sunspot activity may warrant a slight increase of chance of S1 radiation storming over the next few days, though at present the most significant active regions are in the eastern hemisphere of the solar disc. As a result any large flares are less likely to cause Solar Radiation Storms at Earth.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	2	3	4	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux, as observed by GOES-16, is currently at normal Background levels. There is a possibility that solar winds may increase further over the next 48 hours, preventing electrons to accumulate in the Van Allen belts. As the influence of CH32 starts to wane on Days 3 and 4 however, the electron flux is likely to rise and become moderate or perhaps high, particularly at the end of the period.

The latest REFM model does show a forecast gradual rise in fluence over the next 72 hours, and while this is expected to hold true in general, it is considered to be more a reflection of what happened on the last rotation and therefore not useful on this instance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	10	20	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: Latest REFM, not considered to provide good guidance

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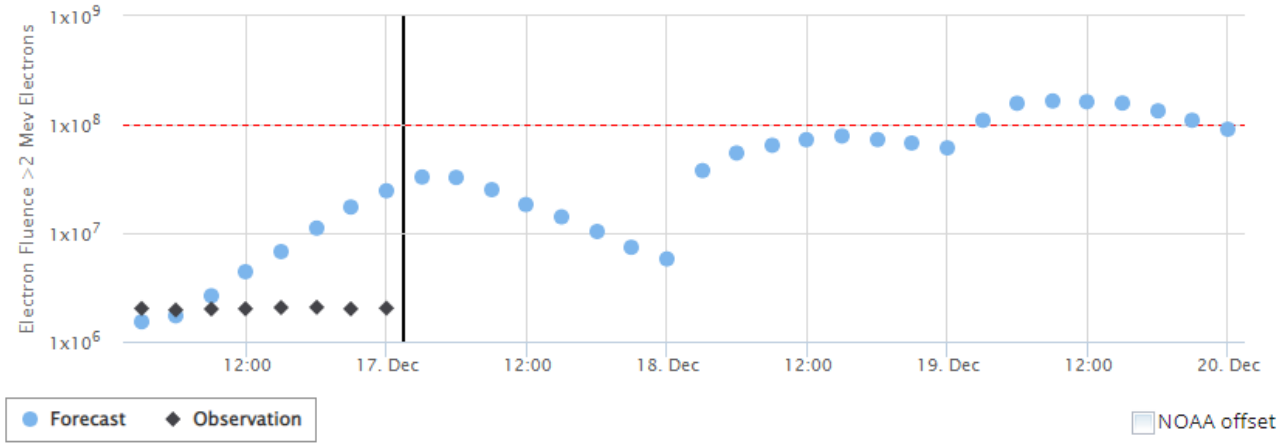

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